[Name of the Document] Specification

[Title of the Invention] Plasma display panel and manufacturing method thereof

[Claims]

[Claim 1] A plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that said protective layer contains carbon and silicon.

[Claim 2] A plasma display panel as defined in Claim 1, wherein the protective layer is composed of magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[Claim 3] A manufacturing method of plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that it comprises a film making process using a protective layer material containing carbon and silicon.

[Claim 4] A manufacturing method of plasma display panel as defined in Claim 3, wherein the protective layer material is composed of magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[Claim 5] A manufacturing method of plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode

and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that, after a protective layer is formed in a way to cover the dielectric layer, carbon and silicon are added to said protective layer.

[Claim 6] A protective layer material of a plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that said protective layer material contains carbon and silicon.

[Claim 7] A protective layer material of a plasma display panel as defined in Claim 6, wherein the protective layer material is magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a plasma display panel (hereinafter abbreviated as "PDP") used for image display device, etc., and a manufacturing method thereof.

[0002]

[Background Art]

An AC surface discharge type PDP is constructed by disposing a front substrate forming a plurality of display electrodes composed of a scanning electrode and a sustain electrode, and a back substrate forming a plurality of address electrodes in a way to be orthogonal to the display electrodes, face to

face in a way to form a discharge space between the substrates and sealing the surrounding area, and enclosing a discharge gas such as neon, xenon, etc. in the discharge space. The display electrodes are covered by a dielectric layer, and on this dielectric layer is formed a protective layer. This protective layer is formed, generally, by using a material with high spatter resistance such as magnesium oxide (MgO), etc., to protect the dielectric layer from ion shocks produced with a discharge. Moreover, each display electrode forms a single line, and a cell is formed at the portion where the display electrode and the address electrode cross each other.

[0003]

On such a PDP, one field (1/60 sec) for image signal is constituted by a plurality of subfields, each having a luminance weight, and each subfield has an address period for writing data by generating writing discharge in the cell to be lit while scanning sequentially line by line, and a sustain period for lighting the cell by generating discharge a number of times corresponding to the weight of brightness in the cell in which the data is written.

[0004]

By the way, in the case of display of TV images, it is necessary to perform writing discharge in each line in a shorter time if the number of lines (number of scanning lines) increases as the cell structure becomes finer, because all actions of the respective subfields must be terminated within a single field. Namely, it is necessary to perform a high-speed drive, during the address period, by narrowing the pulse width of the pulse to be applied to the address electrode for generating writing discharge. However, because of existence of "delayed discharge" which is a discharge made a certain time

after the rise of pulse, there were cases where the probability of termination of discharge during the application of pulse width drops, making it impossible to perform the writing of data in the cell to be lit, thus deteriorating the display quality, in case a high-speed drive as mentioned above is attempted.

[0005]

As main cause producing the above-mentioned delayed discharge, it is suspected that primary electrons serving as trigger at the start of discharge may be difficult to be discharged into the discharge space from the protective layer. For that reason, it is expected that a study of protective layer may eventually lead to improvement of display quality.

[0006]

Under such situation, there is a report that, by impregnating a protective layer composed of MgO with silicon (Si), the amount of discharge of secondary electron increases, enabling to improve display quality (see patent literature 1, for example).

[0007]

[Patent literature 1]

Japanese Laid-Open Patent Application No. H10-334809

[0008]

[Problem to be Solved by the Invention]

However, in the case where a protective layer composed of MgO is impregnated with silicon (Si), it presents a problem that the electron discharge capacity greatly varies with the temperature of the protective layer, changing the grade of image display depending on the environmental

temperature during the use of PDP.

[0009]

The objective of the present invention, realized for solving such problem, is to shorten the delayed discharge time to secure an excellent responsiveness of generation of discharge to application of voltage and, at the same time, control changes against temperature of that delayed discharge time.

[0010]

[Means to Solve the Problems]

To achieve the above-mentioned objective, the plasma display panel according to the present invention is a plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that said protective layer contains carbon and silicon.

[0011]

[Preferred embodiment of the invention]

Namely, the invention described in Claim 1 of the present invention is a plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and a sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that said protective layer contains carbon and silicon.

[0012]

Moreover, the invention described in Claim 2 of the present invention is an invention as defined in Claim 1, wherein the protective layer is

composed of magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[0013]

The invention described in Claim 3 of the present invention is a manufacturing method of plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that it comprises a film making process using a protective layer material containing carbon and silicon.

[0014]

Furthermore, the invention described in Claim 4 of the present invention is an invention as defined in Claim 3, wherein the protective layer material is composed of magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[0015]

The invention described in Claim 5 of the present invention is a manufacturing method of plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that, after a protective layer is formed in a way to cover the dielectric layer, carbon and silicon are added to said protective layer.

[0016]

The invention described in Claim 6 of the present invention is a protective layer material of a plasma display panel comprising a dielectric layer formed in a way to cover a scanning electrode and sustain electrode formed on a substrate, and a protective layer formed in a way to cover said dielectric layer, characterized in that said protective layer material contains carbon and silicon.

[0017]

Still more, the invention described in Claim 7 of the present invention is an invention as defined in Claim 6, wherein the protective layer material is magnesium oxide in which the range of density of carbon is 10 wt ppm ~ 4500 wt ppm, and the range of density of silicon is 30 wt ppm ~ 10500 wt ppm.

[0018]

A preferred embodiment of the present invention will be explained below, with reference to drawings.

[0019]

Fig. 1 is a perspective view showing, with a cut, part of the AC surface discharge type PDP. This PDP is constructed by disposing front panel 1 and back panel 2 face to face to form discharge space 3 between the two, and by enclosing discharge gas composed of neon and xenon in discharge space 3.

[0020]

Front panel 1 is constructed as described below. Namely, on front substrate 4 which is a glass substrate, a plurality of display electrodes 7 composed of scanning electrode 5 in the shape of stripes and sustain

electrode 6 in the shape of stripes are formed, and light-shielding layer 8 is formed between display electrodes 7 adjacent to each other. And, dielectric layer 9 is formed in a way to cover display electrodes 7 and light-shielding layer 8, while protective layer 10 composed of MgO containing carbon (C) and silicon (S) is formed in a way to cover dielectric layer 9.

[0021]

Back panel 2 is constructed as described below. Namely, on back substrate 11 which is a glass substrate, a plurality of address electrodes 12 in the shape of stripes are formed in a way to be orthogonal to scanning electrode 5 and sustain electrode 6, while electrode protective layer 13 is formed in a way to cover address electrode 12. And, on this electrode protective layer 13 and in a way to be positioned between address electrodes 12, partition 14 parallel to address electrode 12, and phosphor layer 15 is formed between partitions 14. Electrode protective layer 13 is formed in a way to cover address electrode 12 plays the role of protecting address electrode 12 and reflecting visible light generated by phosphor layer 15 on the front panel 1 side.

[0022]

Each display electrode 7 constitutes a single line, and a cell is formed at the portion where display electrode 7 and address electrode 12 cross each other. A display is made as discharge is generated in discharge space 3 of each cell, and the visible light in 3 colors or red, green and blue generated from phosphor layer 15 passes through front panel 1.

[0023]

Fig. 2 is a block diagram showing an approximate construction of an

image display device constructed by connecting a drive circuit to PDP indicated in Fig. 1. As shown in Fig. 2, address electrode drive unit 17 is connected to address electrode 12 of PDP 16, scanning electrode drive unit 18 is connected to scanning electrode 5 of PDP 16, and sustain electrode drive unit 19 is connected to sustain electrode 6 of PDP 16, respectively.

[0024]

Fig. 3 is a drawing for explaining the driving method of the image display device an approximate construction of which was indicated in Fig. 2. Generally an AC surface discharge type PDP adopts a system of expressing gradation by splitting the image of one field into a plurality of subfields. And, in this system, one (1) subfield is constituted with four (4) periods comprising setup period, address period, sustain period and erase period. Fig. 3 is a time chart indicating the driving waveform in 1 subfield.

[0025]

In Fig. 3, electric charge on the wall uniformly accumulates in all cells in PDP, to facilitate generation of discharge during the setup period. During the address period, writing discharge of the cell to be lit is made. During the sustain period, the cell in which writing was made in the address period is lit, and that lighting is sustained. During the erase period, the lighting of the cell stops with erasure of the electric charge on the wall.

[0026]

During the setup period, an initialization pulse is applied to scanning electrode 5, for applying a voltage higher than that of address electrode 12 and sustain electrode 6 to scanning electrode 5, so as to generate discharge in the cell. The electric charge generated with this discharge accumulates

on the wall face of the cell in a way to offset the difference of potential among address electrode 12, scanning electrode 5, and sustain electrode 6. As a result, negative electric charge accumulates as wall electric charge on the surface of protective layer 10 in the vicinity of scanning electrode 5, while positive charge accumulates as wall electric charge on the surface of phosphor layer 15 in the vicinity of address electrode 12 and on the surface of protective layer 10 in the vicinity of sustain electrode 6. Because of this wall electric charge, a wall potential of prescribed value is produced between scanning electrode 5 and address electrode 12, and between scanning 5 electrode and sustain electrode 6.

[0027]

During the address period, a scanning pulse is applied to scanning electrode 5, and a data pulse is applied to address electrode 12, for applying a voltage lower than that of address electrode 12 and sustain electrode 6 to scanning electrode 5, in the case where the cell is lit. Namely, a voltage is applied, between scanning electrode 5 and address electrode 12, in the same direction as the wall potential, and a voltage is applied also between scanning electrode 5 and sustain electrode 6, in the same direction as the wall potential, so as to generate writing discharge. As a result, negative electric charge accumulates on the surface of phosphor layer 15 and on the surface of protective layer 10 in the vicinity of sustain electrode 6, while positive charge accumulates as wall electric charge on the surface of protective layer 10 in the vicinity of scanning electrode 5. This produces a wall potential of prescribed value between sustain electrode 6 and scanning electrode 5.

[0028]

During the sustain period, first a sustain pulse is applied to scanning electrode 5, for applying a voltage lower than that of sustain electrode 6 to scanning electrode 5. Namely, a voltage is applied, between sustain electrode 6 and scanning electrode 5, in the same direction as the wall potential, so as to generate sustain discharge. As a result, it becomes possible to start lighting of the cell. After that, by applying pulses in such a way that the polarity alternates between sustain electrode 6 and scanning electrode 5, it becomes possible to emit pulses intermittently.

[0029]

During the erase period, application of erase pulses of narrow width to sustain electrode 6 generates an incomplete discharge and the wall electric charge disappears, to perform erasure.

[0030]

Here, the time from this application of voltage between scanning electrode 5 and address electrode 12 to the generation of writing discharge is a delay of discharge. Still more, in case no discharge took place during the address time of respective scanning electrodes 5, a writing failure is produced and no sustain discharge is generated, and this failure appears as flickering in the display image. Yet more, with further progress of finer resolution, the address time allocated to each scanning electrode 5 becomes shorter, causing a higher probability of writing failure.

[0031]

PDP according to the present invention is characterized by the material constituting protective layer 10, and its density will be explained

below based on a concrete example.

[0032]

In the first place, the apparatus used for deposition process for forming protective layer 10 as described above is generally constituted with a preparation chamber, a heating chamber, a deposition chamber and a cooling chamber, and the substrate is conveyed in this order, to form a protective layer made of MgO. At that time, in the preferred embodiment, a MgO deposition source with controlled Si and C components is used as protective layer material, and is heated in an oxygen ambiance with a piercing type electron beam gun as heating source, to form protective layer 10 by a film making process for forming a desired film. Here, the amount of electron beam current, amount of partial oxygen pressure, substrate temperature, etc. during the film making may be set optionally, because they do no have any great influences on the composition of the protective layer after the film making. Following is an example of the setting of conditions for the film making.

[0033]

Degree of vacuum achieved: 5.0×10^{-4} Pa or under

Substrate temperature at deposition: 200℃ or over

Pressure at deposition: 3.0×10^{-2} Pa ~ 8.0×10^{-2} Pa

In the manufacturing method of protective layer described above, only the deposition process is described. However, other processes such as spatter process, ion plating process, etc. may also be used and, also in that case, the film making may be made all right, by performing component control of the target material and the raw material, and using that material.

[0034]

Moreover, instead of a method using a protective layer material submitted to component control in advance, it may be all right to add elements during the making of film of the protective layers. For example, a means using a gas containing Si, C as ambient gas may be acceptable, during the making of film of the protective layers by deposition.

[0035]

Furthermore, it is also all right to add elements to the protective layers, after the formation of protective layers by film making. In that case, high purity MgO film is made first, and then ion injection of C element and Si element is performed. By using the ion injection method, it becomes possible to form protective layers containing C element and Si element the density of which is accurately regulated. Following is an example of set conditions for performing ion injection:

[0036]

Dosed quantity: $10^{11}/cm^2$-$10^{16}/cm^2$

Acceleration voltage: 10keV-150keV

Still more, as other methods of adding elements after film making of the protective layers, one may use a method by plasma doping in gas ambiance containing C, Si, or a method performing thermal diffusion, by making Si, C film after forming high purity MgO film.

[0037]

Next, explanation will be made on the effects obtained through addition of C element and Si element to a protective layer made of MgO.

[0038]

Firstly, a plurality of different kinds of MgO deposition source with different C density and Si density to be added were prepared, as protective layer material. Here, the density of C was set in the range from 0 to 6600 wt ppm, and the density of Si was set in the range from 0 to 15400 wt ppm. And, protective layers were formed by using various kinds of MgO deposition source, and the delayed discharge time of the panel having these protective layers was measured under the environments of an ambiance temperature of –5℃ to 80℃ of the panel. And, the activation energy of the delayed discharge time was determined from the results of this measurement. Table 1 indicates such results.

[0039]

[Table 1]

Si density (wt ppm)	C density (wt ppm)	Relative ratio of activation energy
7	3	1.17
30	10	0.95
70	30	0.67
210	90	0.43
350	150	0.56
700	300	0.67
2100	900	0.66
3500	1500	0.67
7000	3000	0.70
8400	3600	0.73
10500	4500	0.75
14000	6000	0.78
15400	6600	0.88

[0040]

Delayed discharge time as mentioned here refers to the time from the application of voltage between scanning electrode 5 and address electrode 12

to the generation of discharge (writing discharge), during the address period. Observation was made by generating writing discharge in the respective panels having a protective layer formed by using various kinds of MgO deposition source. The time at which a peak of emission of writing discharge was determined as time of occurrence of discharge, and the amount for 100 times of this emission of writing discharge was averaged. Furthermore, activation energy is a value showing changes in the characteristics against temperature (delayed discharge time in this preferred embodiment), and the lower the value of activation energy the less the characteristics vary against temperature. Table 1, which takes up a case in which 300 wt ppm of Si only was added to MgO as conventional example, indicates the relative ratio of activation energy with the activation energy at that time as 1. In the case where only Si was added to MgO, the value of this activation energy was about constant, regardless of the added density of Si.

[0041]

As it can be seen from Table 1, it was when the density of C was no less than 10 wt ppm and the density of Si was no less than 30 wt ppm that the activation energy value dropped compared with the conventional example in which only Si was added to MgO. In addition, at a C density no more than 4500 wt ppm and a Si density no more than 10500 wt ppm, the delayed discharge time became about the same compared with the conventional example, and became shorter compared with a panel having a protective layer composed of MgO with no additive at all. However, the delayed discharge time either increased or the voltage value necessary for

the discharge became unusually high, when the C density exceeded 4500 wt ppm and the Si density exceeded 10500 wt ppm, making it impossible to display images with the conventional set voltage value.

[0042]

Namely, a panel having a protective layer formed by using a MgO deposition source in which the C density is set at 10 wt ppm to 4500 wt ppm and the Si density is set at 30 wt ppm to 10500 wt ppm can display images without any change to the conventional set voltage value, and can control changes against time of delayed discharge time.

[0043]

Although no clear phenomena can be grasped, this is probably because the factor which strengthened the temperature characteristics can be eliminated with an addition to MgO of not simply Si but Si and C. Moreover, the protective layer by this preferred embodiment, which forms an impurity level between the valence band and the conduction band and has an excellent electron discharging capacity, excels in responsiveness of generation of discharge against application of voltage with a short delayed discharge time and can display clear images without any visible flickering.

[0044]

Furthermore, about the film making method by deposition, it has already been confirmed that the protective layer deposited by using protective layer material in which Si and C of the above-mentioned density were added shows Si and C density of about the same values.

[0045]

From those things, by using a protective layer obtained by

impregnating MgO with C and Si, C being added especially in the range of 10 wt ppm to 4500 wt ppm and Si in the range of 30 wt ppm to 15000 wt ppm, as protective layer material, it becomes possible to shorten the delayed discharge time, and control changes due to temperature of delayed discharge time. Namely, a protective layer having an excellent electron discharge capacity can be obtained, and that electron discharging capacity becomes almost unchangeable against temperature. As a result, it becomes possible to maintain excellent panel display characteristics, regardless of the environmental temperature with PDP using the present invention.

[0046]

[Advantages of the Invention]

As described above, according to the present invention, it becomes possible to obtain a plasma display panel having an excellent responsiveness of generation of discharge against application of voltage with a short delayed discharge time, and enabling to control changes against temperature of the delayed discharge time, and display images clear images.

[Brief Description of the Drawings]

Fig. 1 is a perspective view showing part of the plasma display panel according to a preferred embodiment of the present invention.

Fig. 2 is a block diagram showing an example of an image display device using the above-mentioned panel.

Fig. 3 is a time charge showing the driving waveform of the above-mentioned panel.

[Description of the Reference Numerals and Signs]

1: Front panel

2: Back panel

4: Front substrate

5: Scanning electrode

6: Sustain electrode

9: Dielectric glass layer

10: Protective layer

[Name of the Document] Abstract

[Abstract]

[Object] The present invention aims at securing, on a plasma display panel, an excellent responsiveness of generation of discharge by shortening delayed discharge time, and controlling changes in that delayed discharge time against temperature.

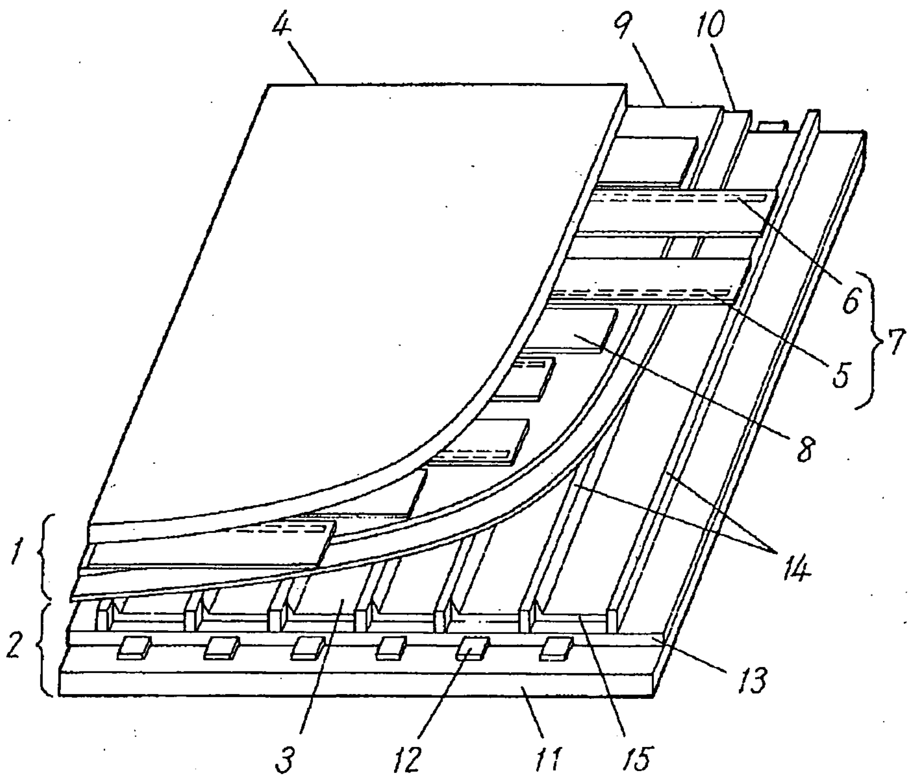
[Means to Solve the Problems] A plasma display panel comprising dielectric layer 9 formed in a way to cover scanning electrode 5 and sustain electrode 6 formed on front substrate 4, and protective layer 10 formed in a way to cover this dielectric layer 9, wherein protective layer 10 contains carbon and silicon, and protective layer 10 is composed of magnesium oxide containing carbon C in the range of density of 10 wt ppm to 4500 wt ppm and silicon in the range of density of 30 wt ppm to 10500 wt ppm

[Selected Drawing] Fig. 1

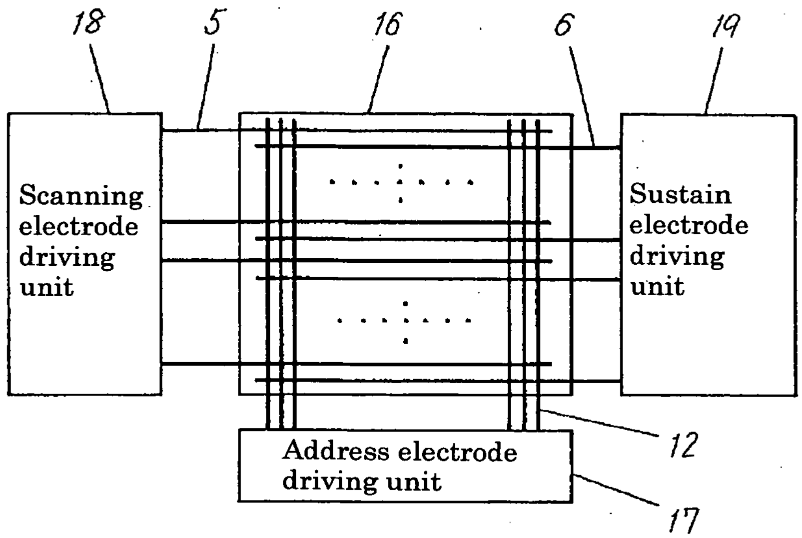
[Name of the Document] Drawing

[Fig. 1]

4: Front substrate
5: Scanning electrode
6: Sustain electrode
9: Dielectric glass layer
10: Protective layer

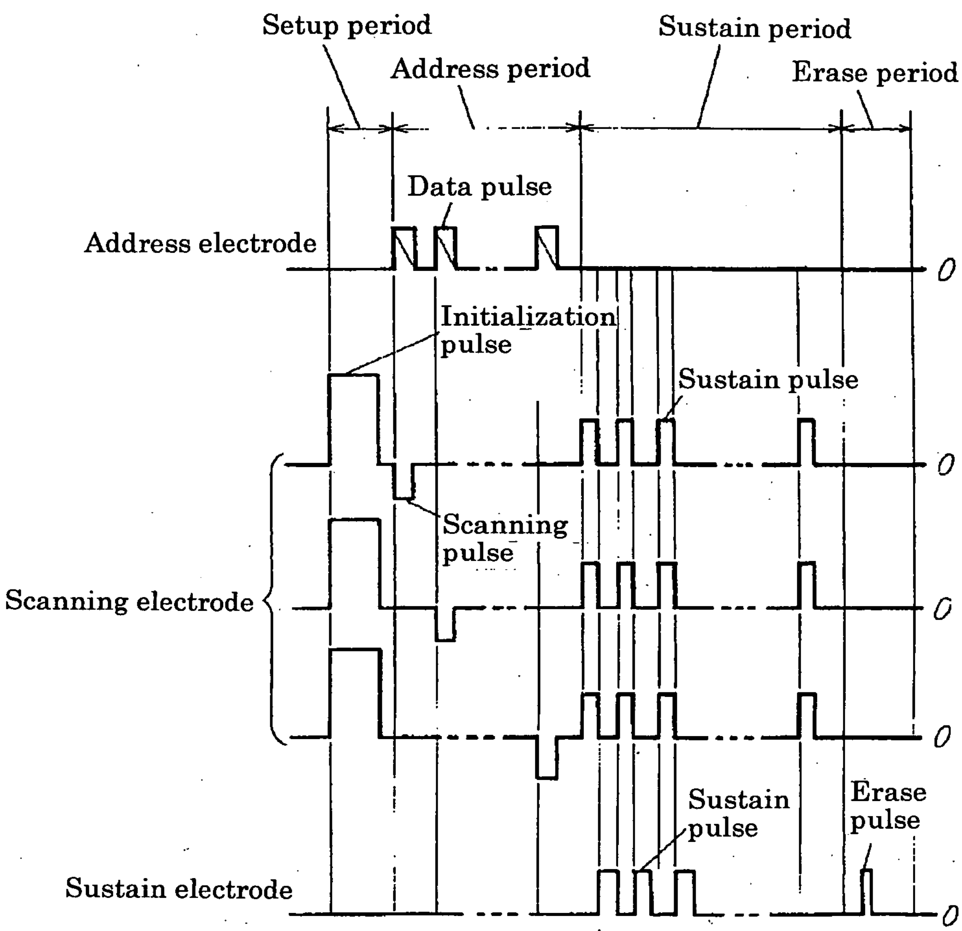


[Fig. 2]



18
5
16
6
19
Scanning electrode driving unit
Sustain electrode driving unit
Address electrode driving unit
12
17

[Fig. 3]



Setup period
Address period
Sustain period
Erase period
Data pulse
Address electrode
0
Initialization pulse
Sustain pulse
0
Scanning pulse
Scanning electrode
0
0
Sustain pulse
Erase pulse
Sustain electrode
0